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ABSTRACT

Lakes and wetlands make up that part of Kentucky's water bodies commonly referred to as standing waters. These waters serve many purposes for the people of the state and are necessary and valued elements of its natural resources. This field guide was designed to provide useful background information and reference material for the study of these areas. The guide is useful for Water Watch--a public participation program that encourages citizens to adopt a stream, lake or wetland, and then gain hands-on experience in protecting and enhancing their adopted water resource. The first chapter consists of a description of the various standing waters and provides an explanation of various terms and concepts in aquatic ecology. Chapter 2 describes the aquatic life one would expect to find in the waters of Kentucky. The third chapter discusses various methods that can be used to survey this kind of habitat. A list of 49 references and field guides follows this chapter. Appendices include how to diagnose the quality of an aquatic habitat; a sample field survey sheet; a key to identifying benthic macroinvertebrates; and a glossary of terms. (CW)

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A Field Guide to Kentucky Lakes and Wetlands

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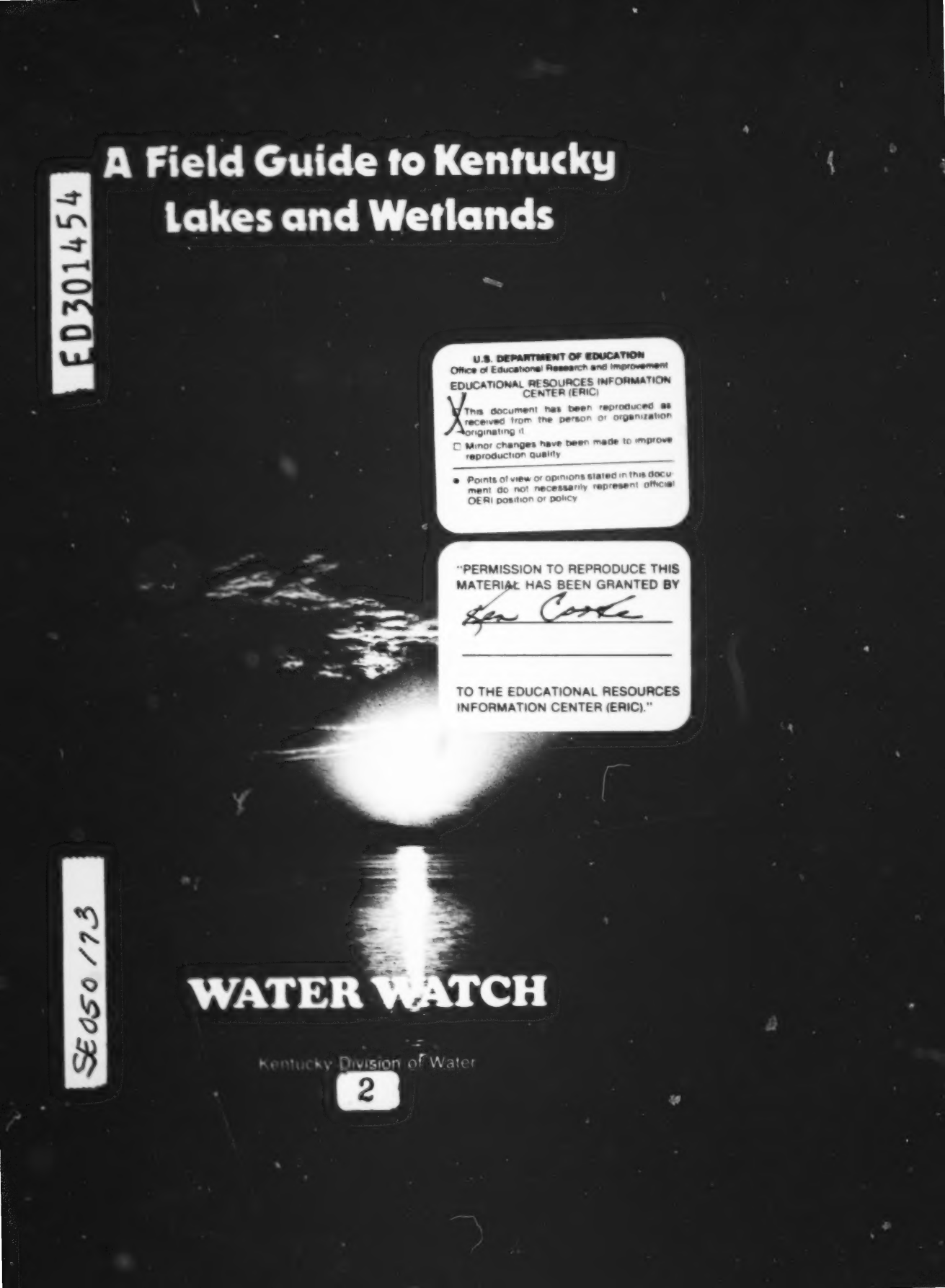

SE 050 173

WATER WATCH

Kentucky Division of Water

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A Field Guide to Kentucky Lakes and Wetlands

This field guide was especially developed for WATER WATCH --public participation program that encourages citizens to adopt a stream, lake or wetland, and then gain hands-on experience in protecting and enhancing their adopted water resource.

This booklet offers an illustrated guide and discussion for field observation along and within Kentucky's lakes and wetlands. The Kentucky Division of Water hopes it will serve as a working tool in providing your WATER WATCH group a rewarding learning experience and a greater appreciation of our precious water resources.

Help Yourself to Clean Water
Adopt a Stream, Lake or Wetland

WATER WATCH
DIVISION OF WATER

Kentucky Natural Resources and
Environmental Protection Cabinet
May 1985
(Revised May 1986)

All art work and figures by Ann Disalvo.

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CHAPTER 1 ECOLOGY

Lakes and wetlands make up that part of Kentucky's water bodies commonly referred to as standing waters. A **lake** can generally be defined as a body of standing water occupying a definite basin. A small lake, usually shallow enough to allow growth of rooted plants from one shore to the other, is commonly referred to as a **pond**. **Wetlands** are areas that are not deep enough to be called a lake, but are covered with water or have saturated soil at least part of the year. If the wetland supports shrubs and/or relatively large trees such as cypress and gum, it is classified as a **swamp**. If the wetland is treeless and is occupied by grasses, rushes and sedges, it is referred to as a **marsh**. All of these water bodies serve many purposes for the people of Kentucky and are necessary and valued elements of the state's natural resources.

Lakes

The Zones and Life-Groups of Lakes

A quick look at a lake might lead you to believe that it is just a large body of water, pretty much the same throughout. Actually, the lake can be divided into a number of regions (Figure 1), each with its own features and characteristic forms of life. The region of free, open water is called the **pelagic zone** and is inhabited mostly by tiny organisms called **plankton**. Animal components of the plankton are called **zooplankton** and plant components are designated **phytoplankton**.

The shallow region around the edge of the lake, from the highest seasonal water level to the depth where light cannot reach the bottom, is called the **littoral zone**. This is the major zone of large plants **(macrophytes)** in a lake. Closest to shore (0-5 feet deep) is a band of **emergent** plants (cattails are an example) that rise above the water surface. Proceeding out from shore, this is followed (2-10 feet deep) by a band of **floating-leaved** plants such as water lilies. Extended further outward to the depth of maximum light penetration is a band of **submerged** plants that do not reach the surface. The depths of these zones vary according to the nature of individual lakes, and plants characteristic of one zone are often found in others.

The littoral zone is an area of great productivity and, as any fishing enthusiast will tell you, provides cover and breeding areas for many species of fish, as well as the animals and plants on which they feed. Thus, protection of the littoral zone is critical to the life of the entire lake ecosystem.

We mentioned that the tiny, even microscopic, life that occures in the open water is called plankton. You might also like to know the names of other life-groups of the lake. The animals that live on or in the bottom of the lake are called the **benthos**, or **benthic organisms**. Those benthic animals that are large enough to be seen with the naked eye are called **macrobenthic** organisms. Examples are freshwater clams and crayfish. Also, fish and other free-swimming animals are sometimes referred to as the **nekton**.

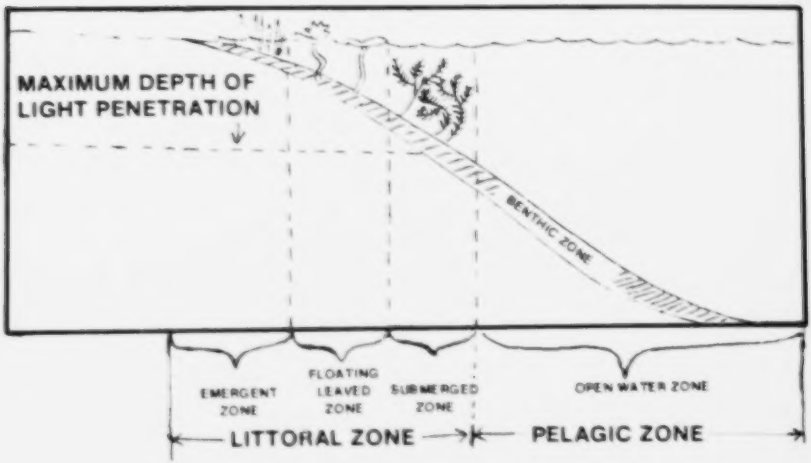


Figure 1. The Life Zones of a Lake.

The Seasonal Cycle of Lakes

The internal structure of most lakes in Kentucky changes with the seasons. There is a cycle whereby the lake becomes **stratified,** or layered, based on the temperatures of the various

layers. This cycle, starting in late Spring/early Summer, proceeds in the following fashion. After the ice melts, but before the water starts to warm up, the lake is almost uniform in temperature from top to bottom. Gradually, as the days grow longer and the sun climbs higher in the sky, the water at the surface of the lake becomes warmer. This produces a **density difference** between the warmer, less dense (lighter) surface waters and the colder, more dense (heavier) deeper waters. As the temperature difference between surface and deeper waters increases, so does the density difference, until a **density discontinuity** (barrier) is produced. The densities of the surface and deeper water masses are different enough that they no longer mix easily with one another.

The result of this process is the establishment of three layers in the lake during the summer season: an upper warm layer called the **epilimnion**; a lower cold layer called the **hypolimnion**; and a narrow layer of rapid temperature change in between called the **thermocline** (Figures 2 and 3). This is **thermal stratification** of a lake. Undoubtedly, most of you have felt the temperature difference of these layers as you have dived into a lake in the summertime.

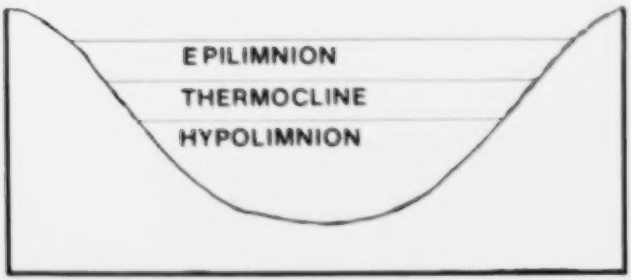


Figure 2. Thermal stratification of a lake during the period of summer stagnation.

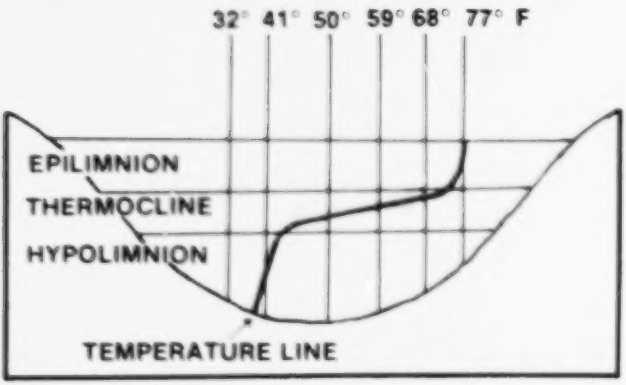


Figure 3. Temperature profile of the layers of a typical stratified lake during the period of summer stagnation. Note the rapid decline in temperature as you pass through the thermocline.

The establishment of this stratification has important consequences for the lake and its inhabitants. Since the upper and lower layers are separated from one another, the only circulation that can occur is in the epilimnion (surface layer) as winds move the surface waters. Oxygen enters the water through contact with air, or from production by the phytoplankton. The hypolimnion (deep layer) is effectively cut off from a supply of oxygen during this **period of summer stagnation**. If some process uses up the oxygen left in the hypolimnion, most animal life in these deeper waters will die. Indeed, as you will see later, this does happen under certain polluted conditions.

As air temperatures cool in the Autumn, the waters of the epilimnion also cool, eventually reaching a temperature equal to that of the hypolimnion. Now there is no longer a density difference. At this point, winds will mix the waters of the lake from top to bottom - top waters circulate to the bottom and bottom waters to the top. We say the lake "turns over," and call this the **period of fall turnover**. The temperature of the water at the time of fall turnover is approaching 39° F, the temperature where water is the heaviest (most dense). The arrival of winter

cools the air and surface water further, until it reaches 32° F, the freezing point. Since water is heaviest at 39° F, this colder water between 39° F and 32° F is lighter than the water below it that is still at 39° F. The result is another stratified situation with the thin top layer now being **colder**, but still lighter, than the water below it. This is not as strong as the summer stratification, but as ice forms on the surface, circulation is shut off from the whole lake. This is called the **period of winter stagnation**. Since Kentucky lakes do not always freeze over, they may remain in circulation all winter, effectively "skipping" the period of winter stagnation.

With the arrival of Spring, the ice layer melts and the surface waters become warmer. Now winds can circulate the waters from top to bottom again, causing the **period of spring turnover**. This brings us back to the point at which we started the seasonal cycle. As you can see, the lake environment changes much more than most people realize.

Cultural Eutrophication

One of the major problems faced by lakes todays is a process called **cultural eutrophication**, whereby lakes receive an excess of nutrients such as nitrogen and phosphorous. At first glance, the addition of nutrients might seem like a good idea, but combined with the types of plant life in the lake and the cycle of stratification we just discussed, you can overfeed a lake to the point that it changes to an entirely different habitat.

The phytoplankton of a lake is made up of algae. These tiny organisms, if given enough food, reproduce very fast. In fact, lakes often experience a spring bloom of algae under normal conditions. When the warmer waters of late Spring combine with nutrients brought up from deep waters during the Spring turnover, ideal conditions for algal growth are produced. Normally, however, the algae quickly use up the food supply, making the bloom short-lived. This is the process of **natural eutrophication**.

The problem of **cultural eutrophication** arises when, along with the natural food supply, nutrients from sewage, agricultural runoff or other sources are fed into the lake, producing an essentially limitless supply of food for the algae. Presented with this contiuing source of food, the algal population continues to grow in the epilimnion as the period of summer stagnation is reached. Because of the following chain of

events, this situation can lead to serious impairment of the lake as an enjoyable, productive resource.

Individual algal organisms are short-lived. As more and more are produced, more and more also die and sink through the thermocline and on into the hypolimnion. You will remember that during the period of summer stagnation the hypolimnion is cut off from a supply of oxygen. All that is available is the oxygen that was dissolved in the water when stratification occurred. Normally, this is enough to reach fall turnover, but decay and decomposition of the dead algae sinking down from the surface layers use large amounts of oxygen. They can, in fact, use up all of the deepwater oxygen. When this occurs, all animals in the hypolimnion that require oxygen die. At this point, the lake is in a mess. There is an unsightly scum of algae on the surface; gases, such as hydrogen sulfide (the rotten egg smell), produced by decomposition, bubble to the surface; and fish and other animal life are dying or have much less suitable habitats for their existence. When the Fall turnover arrives, the dead and decaying contents of the deep water are brought to the surface. This entire process is called cultural eutrophication since it is caused by the cultural activities of humans.

Sedimentation

One of the biggest sources of water pollution in Kentucky is **sediment**. Sediment is defined as small particles of "dirt" that are carried along by water as it runs off the land. Most sediment comes from accelerated erosion of agricultural and surface-mined land and construction sites. Waters that are heavily polluted with sediment are very obvious because of their "muddy" appearance. This is especially evident in rivers, where the force of moving water keeps the sediment suspended.

However, when the river reaches a lake or reservoir, the water loses speed and the sediment drops to the bottom, a process called **siltation**. Therefore, the lake water looks clear after you move some distance from the point where the river enters. This does not mean, however, that sediment is not a pollution problem in the lakes. As sediment settles, it covers the bottom, smothering the macrobenthic organisms that live there and changing the nature of the lake bottom. What was a sandy or

clay bottom now becomes a "muck" bottom, and few organisms can live in muck. An abundance of sediment in the water can clog fish gills, cover their breeding areas and smother their eggs. If heavy sediment loads are carried into a lake or reservoir over a period of years, they can actually fill the basin and eventually turn it into a wetland, or even dry land. This process is happening in some of our lakes even as you read this.

Toxic Substances

Toxic substances act as poisons. They reach the waters of Kentucky through industrial and municipal wastewater discharges, and in runoff from cities, farms and mining operations. Toxic substances affect aquatic life, and people that drink water or eat fish carrying toxics, in one of four ways. First, the substance can cause immediate danger or death. This is called **acute toxicity**. Second, if the effect is more subtle, producing long-term effects that alter appetite, growth, metabolism or reproduction, it is called **chronic toxicity**. Such action can eventually lead to serious illness, death or mutations.

The third effect concerns toxic substances that enter the water in very low concentrations, so low in fact that they pose no apparent risk at that level. However, many toxics bioaccumulate. **Bioaccumulation** is a process whereby a substance becomes concentrated by the biological organisms that consume it. For example, a particular toxic might be absorbed by a planktonic alga or consumed by a planktonic animal in levels that do not poison them. A minnow, however, eats thousands of these tiny plants and animals, each with its own small amount of the toxic. A bass or trout will eat hundreds of minnows, each with its amount of toxic substance gained from the thousands of pieces of plankton. As you can see, the higher up this "food chain" you go, the more toxin you get with each bite. The substance has been "bioaccumulated." By the time you eat the bass or trout, you can be consuming significant quantities of the toxin. In fact, the bioaccumulated PCB levels of lake trout in Lake Michigan prompted officials in states surrounding the lake to advise fishermen not to eat their catch. Many organic pesticides and heavy metals bioaccumulate.

The fourth possible effect of toxic substances is the production of behavioral modifications. In this case, the organism is not killed, but its behavior is changed. This includes cases where fish or other animals move from the affected area or in some other way alter their normal behavior, such as becoming disoriented, showing increased or decreased aggression, or developing unsuccessful reproductive behavior.

Wetlands

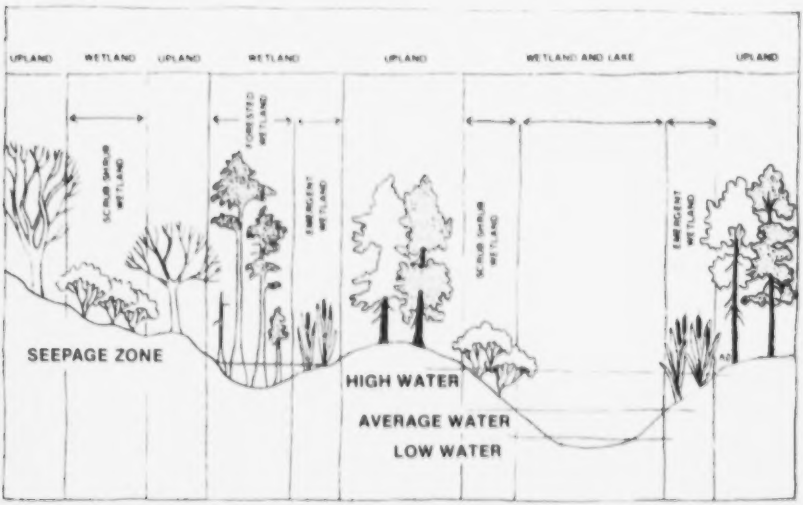
Types of Kentucky Wetlands

Wetlands are areas covered with shallow water (usually less than 6 feet) or with saturated soil at least part of the year and are some of the least understood and most unappreciated environments in Kentucky. At the same time, they are without a doubt some of the most valuable and productive areas of the state. As a group, wetlands include those "wet" habitats commonly called marshes, swamps, bogs, sloughs, potholes, backwaters and mud flats. Technically, wetlands are lands in between dry land and aquatic systems where the water table is at or near the surface of the land most of the time, or the land is covered by shallow water. In these environments, saturation with water is the most important factor in determining the nature of the soil and the kinds of plants and animals that live there. In fact, most wetland plants are classified as **hydrophytes**. These plants are adapted to living in the low-oxygen conditions of saturated soils.

As mentioned in the introduction, a marsh is a treeless wetland occupied by grasses, rushes, and sedges. These are also called **emergent wetlands**, and are similar to the emergent zone around lakes. They support the same types of emergent plants, such as cattails and bulrush and, usually, floating-leaved and submerged plants as well. The **swamp** is a wetland with trees. Actually, the common name "swamp" includes two types of wetlands. The **scrub/shrub wetland** is a swamp dominated by small trees and bushes less than twenty feet in height, such as buttonbush and willow. The **forested wetland** is similar, but is dominated by trees over twenty feet in height, such as cypress and gum. A large part of Kentucky's wetlands are a type of forested wetland called **bottomland hardwoods** which

occur along the floodplains of the Ohio and Mississippi rivers and their tributaries in the western part of the state. However, examples of all three types are scattered throughout the state along rivers and streams (where they may be flooded only part of the year), around lakes, or situated in shallow depressions (Figure 4).

For hundreds of years, wetlands have been regarded as wasted land, land that is better drained or filled and put to more "productive" use. We have now come to realize, after losing



Modified from Cowardin 1979

Figure 4. Examples of Wetland Habitats in Kentucky.

about half of the nation's wetlands, that these areas have their place of importance in the "natural scheme of things." In fact, the more we learn about wetlands, the more we discover about the positive roles they have played and are playing in the wise management of our water, fish and wildlife resources.

Water Management

Filtering Pollutants

Wetlands help prevent the eutrophication problems discussed earlier by absorbing nutrients (Figure 5). These nutrients, especially nitrogen and phosphorus, are used for plant growth. As with all types of ecosystems, however, there is a limit to how many nutrients can be absorbed. Thus, although wetlands can be a great help in reducing the eutrophication problem, we still need to control the sources of excess nutrients. This is also the case with other pollutants, such as pesticides from farm lands and pollution from industry. Wetlands can remove some of these pollutants from the waters by filtering them out, by chemically breaking them down, and by taking them up through root systems, as long as the amounts are not too great.

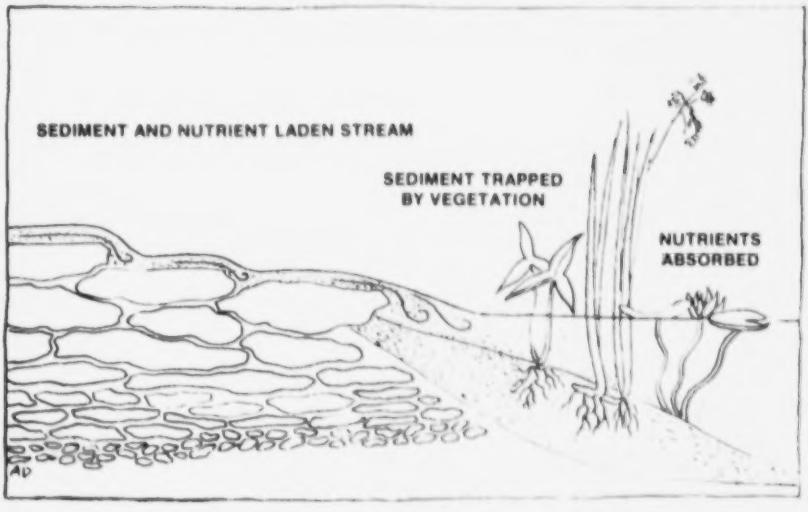


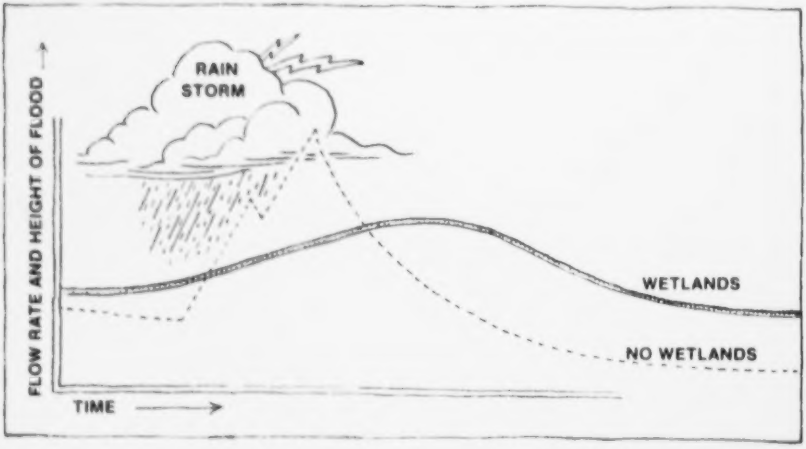
Figure 5. Wetlands Purify Water.

As water passes through a wetland, the dense vegetation slows down the rate of flow. When this happens, many of the sediments carried along by the faster water will settle out.

Thus, wetlands are very helpful in reducing the **turbidity** ("cloudy" or "muddy" appearance) of water and in preventing the filling of lakes and reservoirs by siltation. This effect can be very efficient. For example, one study in Wisconsin found that wetlands, under ideal conditions, can remove 90 percent of the sediments from water.

Flood and Erosion Control

It is now clear that the draining and filling of wetlands associated with floodplain development have been partly responsible for recent major flood disasters throughout the country. Wetlands store water during times of flooding and release it more gradually as the waters recede. This lowers flood crests and slows the rate of flow of flood waters, thus lessening downstream flood damage (Figure 6). In fact, the U.S. Army Corps of Engineers determined that the best way to prevent flooding in the Charles River watershed near Boston,



Modified from Kiesler 1983

Figure 6. Wetlands Reduce Peak Flows and Heights of Floods.

Massachusetts, was to protect the naturally occurring wetlands of the area. Acquiring these wetlands was a cheaper solution than building dams and dikes and provided at least the same

level of protection. Wetlands also reduce shoreline erosion by absorbing the force of water flow along river banks and the force of wave action around lakes, thereby protecting riverfront lands and lakefront homes.

Water Supply and Groundwater Recharge

Waters that are stored in wetlands would otherwise have to travel downstream, thus being lost as a resource to the upstream area. Retention of these waters makes them available for domestic or municipal water supply, livestock watering and irrigation. Thus, wetland protection reduces downstream flood damage and provides future water supplies, whereas dredging or filling increases flood and erosion damage and allows loss of the water resources of upstream regions. Further, many wetlands retain water and allow it to seep into the ground to replenish groundwater supplies, a process called **groundwater recharge**.

Fish and Wildlife Management

Wetland Productivity

Wetlands are among the most productive natural systems in the world -- a far cry from the traditional view of a "wasteland." They are on a productivity level shared only by tropical rain forests and salt marshes (Figure 7). This high level of productivity results from many factors, including nutrient-laden water and the high efficiency rates of wetland plants in converting solar energy into plant material. In the process, these plants add large amounts of oxygen to air and water. Some animals, such as muskrats, feed directly on marsh plants, but most plant material falls to the bottom and breaks apart to form **detritus** (partially decomposed organic material). The detritus is eaten by aquatic insects and other macrobenthic animals that are, in turn, eaten by fish, waterbirds, and other animals. Further, pieces of vitamin-rich detrius and nutrients from its decay are carried along by the water to increase productivity of areas downstream. Wetlands, therefore, function as the "prime farmland" of the aquatic world. Many of our aquatic animals depend on this food source.

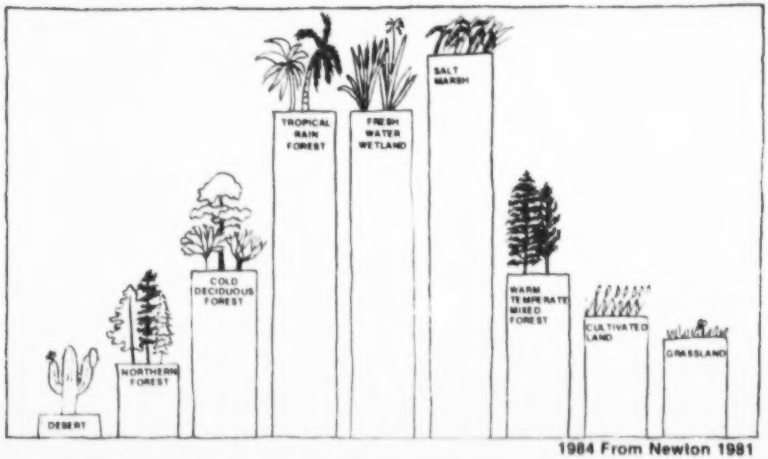


Figure 7. The Relative Productivity of Wetlands in Comparison to Other Selected Environments.

Fish and Wildlife Habitat

Wetland areas along rivers and lakes provide food, spawning grounds, and nursery grounds for such species as largemouth bass, bluegill and other sunfishes, catfish, minnows, carp and many others. Bottomland hardwoods, common in western Kentucky, are especially important areas for spawning and nursery grounds for warmouth sunfish and largemouth bass. It has been shown that river wetlands in Georgia produce up to 1300 pounds of fish per acre.

Wetlands are nearly as important for birds as they are for fish. They provide year-round habitat for resident birds, as well as breeding grounds, overwintering habitats and feeding grounds for migratory species. Perhaps the most familiar wetland inhabitants are waterfowl (ducks and geese) and wading birds (herons, egrets, sandpipers and others). Even wild turkeys nest in bottomland hardwood forests.

These water resources are also home to a diverse array of reptiles, amphibians and mammals. Common residents include muskrats, mink, otter, raccoons, skunks, weasels, numerous

mice and shrews, turtles of all kinds, frogs, toads and salamanders galore. The number of amphibians (such as frogs, toads and salamanders) that can occur in wetlands, especially in the Spring, is nothing short of a minor miracle. For example, in a small forested pond in Georgia, one diligent investigator found 1600 salamanders and 3800 frogs and toads. The pond was less than 100 feet wide!

Endangered and Threatened Species

Kentucky defines a **threatened species** as one which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in Kentucky. Similarly, an **endangered species** is in danger of extirpation and/or extinction throughout all or a significant portion of its range in Kentucky. Many such species are dependent, during at least part of their lifetime, on wetlands. In fact, 35 percent of the rare and endangered animal species listed by the Bureau of Sport Fisheries and Wildlife in 1966 are either located in wetlands or are dependent upon them. Even beyond this, many species of endangered plants require wetlands for their survival. One of the major reasons they are threatened or endangered, of course, is that the habitat upon which their existence depends, the wetland, is approaching an endangered condition itself.

Recreation, Education and Research

Recreation

Perhaps the greatest recreational use of wetlands is for hunting and fishing. Waterfowl hunting is a major wetland activity, and big game hunting is an important activity in some areas, especially in scrub/shrub and forested wetlands. In addition, much of our freshwater fishing is dependent on wetlands since many game fishes require them for spawning or raising young. Wetlands are also important areas for those devoted to bird-watching or other wildlife observation.

Education and Research

Wetlands are one of our most valuable ecosystems for research to understand how plants and animals relate as a community, to study productivity, to investigate aquatic processes and the control of water pollution, and numerous other topics.

In addition, they offer excellent areas for nature study by schools and conservation groups.

Status of Wetlands Today

The average loss of wetlands in the lower 48 states from the mid-1950's to the mid-1970's was over half a million acres per year. About 300,000 acres per year were lost from scrub/shrub and forested wetland, with emergent wetlands losing over 200,000 acres per year. This loss equals an area as large as the combined states of Massachusetts, Connecticut and Rhode Island.

The Kentucky situation is similar to that of the nation. In the early 1950's there were an estimated 273,000 acres of wetlands along the Kentucky shores of the Ohio and Mississippi rivers and their tributaries. In 1977, the estimate had dropped to 147,370 acres. Forty six percent of Kentucky wetlands were lost. The following is a brief description of major reasons for this loss.

Causes of Wetland Loss and Degredation

Drainage

Many wetlands are being drained to convert the land to agricultural uses or for mining purposes. Bottomland hardwoods are especially hard hit since they provide timber as a first stage and are then converted to cropland, usually for soybeans (Figure 8). Much of our prime agricultural land is being developed for non-agricultural uses, forcing conversion of marginal areas, such as wetlands, to farmland. However, the benefits of marginally increased food production, as compared with wetland benefits, need to be re-evaluated in light of the many recently-discovered values of our wetlands. With regard to timber production, selective cutting of bottomland hardwoods can yield valuable returns for hundreds of years and still maintain the economic benefits derived from this type of forested wetland.

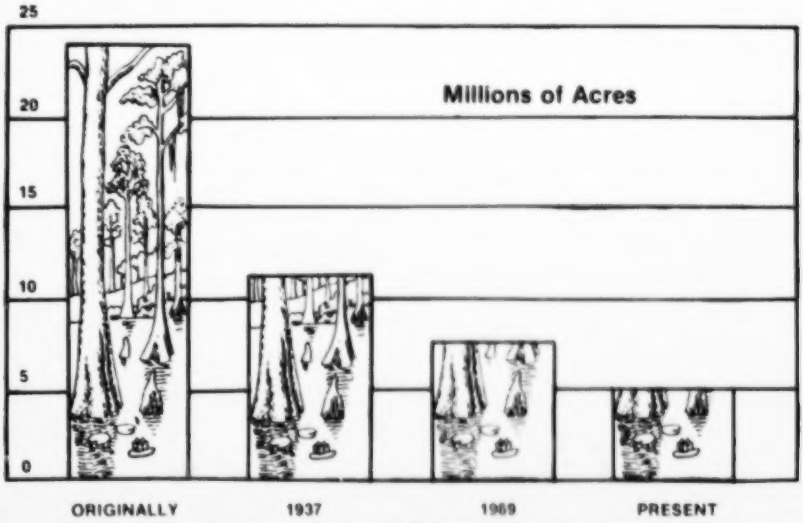


Figure 8. The Extent of Loss of Bottomland Hardwoods in the United States.

Dredging and Stream Channelization

These practices have been an accepted means of flood control for years. Ironically, they have led, in many cases, to increased flood damage further downstream. Displacement of a flooding problem to another area does not solve the problem and actually results in the loss of the natural flood control system, the wetland.

Filling

Wetlands are filled for solid waste disposal, roads and highways, and commercial, industrial and residential development. However, when the wetlands are filled and the water retention ability is lost, these areas become subject to periodic flooding.

Pollutant Discharge

Discharges of pesticides and other toxic substances, nutrients from sewage and agricultural runoff, brines from oil and gas operations, acid drainage from mines and sediments from erosion all can and do affect wetlands. As was mentioned, wetlands can help purify waters of these pollutants, but only to a certain level. The wetland can become overloaded the same as any other habitat.

CHAPTER 2 AQUATIC LIFE

Aquatic Macroinvertebrates

This section introduces you to the world of the macroinvertebrates that inhabit lakes, ponds and wetlands. A simplified and generalized definition of an **aquatic macroinvertebrate** is an organism that spends at least a part of its life cycle in water (aquatic), can be seen without the use of instruments such as a microscope (macro), and lacks a backbone (invertebrate).

When using aquatic macroinvertebrates to study the water quality of a lake, one must be careful not to jump to conclusions about the lake's cleanliness. Unproductive **(oligotrophic)** lakes will not have as many organisms as moderately productive **(mesotrophic)** lakes, but they will have an overall community that suggests unpolluted water. The mesotrophic lakes, however, will have a more diverse aquatic community due to the increased productivity caused by more nutrients entering the system. When a lake becomes highly productive **(eutrophic)**, the macroinvertebrates usually will be represented by only a few species, but each species will have many individuals. This type of community is called a "monotonous" assemblage and is characterized by large numbers of midge larvae, leeches and aquatic earthworms. Due to their ability to live in waters containing low levels of dissolved oxygen, these organisms can occupy and thrive in eutrophic environments. A change in the aquatic macroinvertebrate community from high diversity and low numbers per species to a monotonous assemblage indicates that the lake is shifting from an oligotrophic or mesotrophic to a eutrophic condition. This suggests that the lake is being polluted.

We will now take a brief look at the major aquatic macroinvertebrate groups of lakes and wetlands. For more information on these groups, refer to the sources cited in the Reference Section. For your interest, we have provided the scientific name of the Order or Class to which each of these groups of animals belongs. An Order contains all Families of animals with similar biological characteristics. A Class contains all Orders with similar biological characteristics.

Bryozoa (Class Bryozoa)

- Bryozoans are commonly referred to as moss animals and usually are found in unpolluted and unsilted ponds and shallow areas of lakes. To the casual observer, these colonies are often mistaken for matted algae. Bryozoans can attach together to form encrusting (attaching) or gelatinous masses which may attain the size of a grapefruit or small watermelon.

Isopod (Order Isopoda)

- Isopods are commonly called pill bugs and are similar in shape to a caterpillar flattened front to back with legs extending on either side. They seldom inhabit open waters, but instead remain hidden under rocks, vegetation and debris. Isopods are typical inhabitants of small- to medium-sized streams or wetlands. They are moderately tolerant of organic pollution.

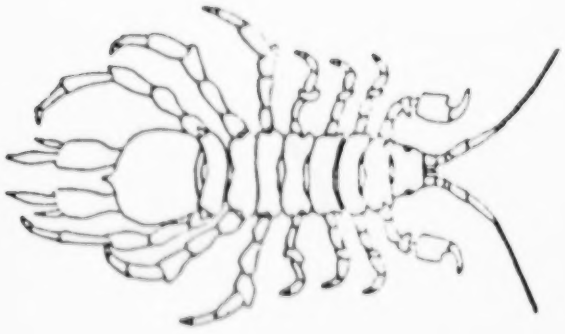


Figure 9. Isopod

Fairy, Tadpole and Clam Shrimp (Order Eubranchiopoda)

- These macroinvertebrates are among the most characteristic inhabitants of temporary ponds and pools during spring and early summer. They are exclusively freshwater animals. Their movements are very graceful and they often

swim upside down. One of the most interesting facts about these shrimp is that they are usually absent from lakes and running waters. Also, they are not often abundant in pools where carnivorous (meat eating) insects are found and are rarely seen where predatory fish live.

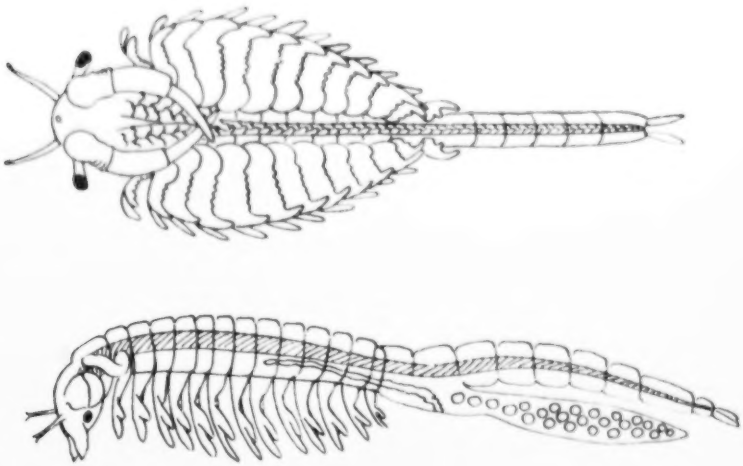


Figure 10. Fairy Shrimp

Amphipods (Order Amphipoda)

Commonly referred to as scuds or side-swimmers, amphipods occur in a wide variety of lakes, ponds and wetlands. They are compressed from side to side, and are usually curled into a half-moon shape. You will most often find them in masses of vegetation around the edges of lakes or in wetlands. They generally prefer clear waters.

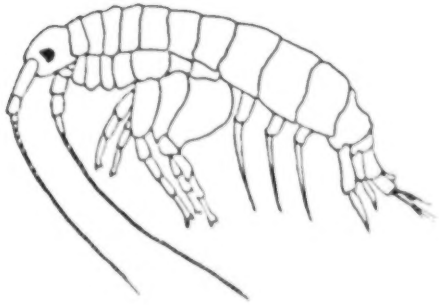


Figure 11. Scud

Mussels (Class Pelecypoda)

- Mussels are found partially or completely buried in sand, gravel or mud bottoms, usually in water less than six feet deep. Several species of pelecypods are found in lakes and wetlands. These bivalves (animals with two shells hinged together) are difficult to see in lake environments. Perhaps the easiest way to find them is to look for their shells at the water's edge where they are commonly left by muskrats and raccoons. Check especially around muskrat houses. Mud bottoms contain different species than sand bottoms, so heavy siltation, as occurs in many reservoirs, will wipe out sand-living species.

Figure 12. Unionid Mussel

Snails (Class Gastropoda)

- Snails are familiar to most of us and can be found creeping over the bottom of lakes and wetlands and crawling about on plants growing in shallow waters, usually less than six feet deep. Sometimes you may have to hunt all day to find just a few snails, while on other days or in other spots they may be present in enormous numbers, especially in the "hard" waters of Kentucky's limestone regions. Areas with low amounts of oxygen have few snails, with the exception of a few air-breathing species.

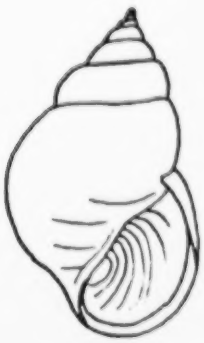


Figure 13. Snail

Crayfish and Freshwater Shrimp (Order Decapoda)

- These macroinvertebrates are prevalent in lakes and wetlands. Most crayfish are burrowers and are rarely seen during the day, although you may find them under rocks or logs. At night, you can find them crawling on the bottom by using a flashlight. As with the mussels (and most other aquatic macroinvertebrates), different types of habitats are home to different species. If the proper habitat and food are available, crayfish can become extremely numerous. They are also relatively pollution-tolerant. Freshwater shrimp are much smaller than crayfish and are almost transparent. Look carefully for them swimming through the water.

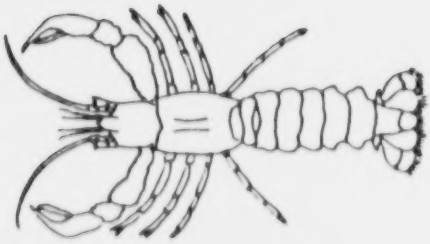


Figure 14. Crayfish

Leeches (Class Hirudinea)

• Leeches have the worst reputation of all our aquatic macroinvertebrates because some are parasitic on livestock and humans. However, most are not parasitic and find food by scavenging and predation. These organisms are often brightly colored and have unique patterns the length of their bodies. They are common inhabitants of our lakes and wetlands. You will find them in shallow warm waters, usually under stones or logs. In general, leeches are nocturnal (night active) animals. Some species can tolerate pollution, but few can live in strongly acid waters.

Figure 15. Leech

Insects (Class Insecta)

The remainder of the groups we will discuss are insects. There are a great number of these individuals that inhabit wetlands. As with many of the organisms discussed above, their presence or absence, and the size of their population in relation to the overall aquatic community, are indicators of water quality.

Mayflies (Order Ephemeroptera)

- Mayflies occur in all types of freshwater during their nymph stage of life as long as there is an abundance of oxygen. They can be found climbing on submerged vegetation or crawling along or plowing their way through the bottom. One type of mayfly emerges *en masse* (all together) when it matures and leaves the water as an adult. The following quote from a 1970 Environmental Protection Agency document illustrates the astounding numbers that can occur.

> *Hexagenia* mayflies tend to emerge *en masse*, and the river residents are accustomed to nuisance problems caused by the insects during periods of maximum emergence. Tree limbs droop under their weight, and drifts of the insects form under street lights where they decay and create objectionable odors. Shoppers desert downtown areas as the large, clumsy insects fly in their faces, cover windows, and blanket sidewalks. In extreme cases, snowplows are called out to reopen bridges which have become impassable.

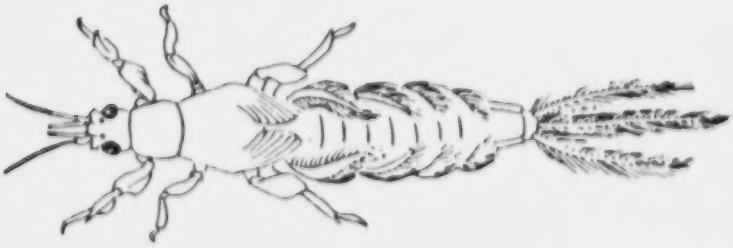
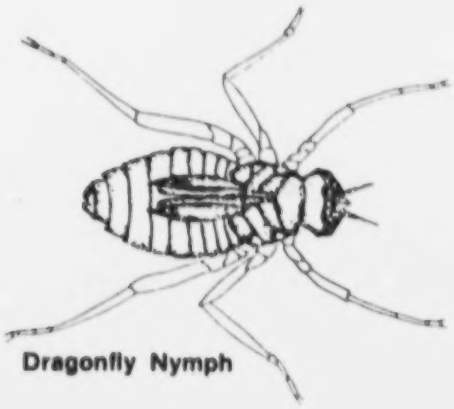


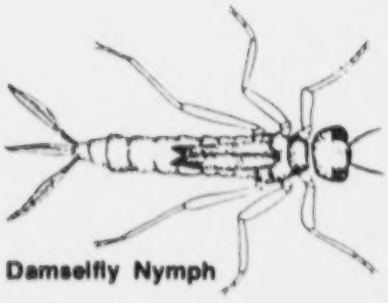
Figure 16. Mayfly Nymph

Dragonflies and Damselflies (Order Odonata)

- These organisms are probably one of the best known groups of aquatic insects. Their general flitting and playing around bodies of water are visible to all. The adults are sometimes called darning needles or mosquito hawks due to their size, shape and feeding habits. The aquatic nymphs are spider-like creatures with a spoon-shaped food-gathering device (the labium) that folds back underneath the head. When prey approaches, it is seized suddenly and effectively by the lightning-like extension and contraction of the labium. All species are predatory. They are commonly found on submerged vegetation, on the bottoms of wetlands and in the shallow areas of lakes.



Dragonfly Nymph



Damselfly Nymph

Figure 17.

Water Boatmen, Back Swimmers and Waterstriders (Order Hemiptera)

- These water inhabitants are among the most interesting of the aquatic insects. They are truly aquatic and remain in or on the water as adults, except to fly to other bodies of water. The first two have long, flattened hind legs, similar to oars, that they use to dart about in the water. Water boatmen and back swimmers can be found on the bottoms of all lakes and wetlands and use only their hind legs to propel themselves through the water, giving them the appearance of "rowing" along. Back swimmers, as their name suggests, swim upside down. Waterstriders actually "walk on water" where they skate about in large groups. All three are predatory and can give a nasty sting when improperly handled.

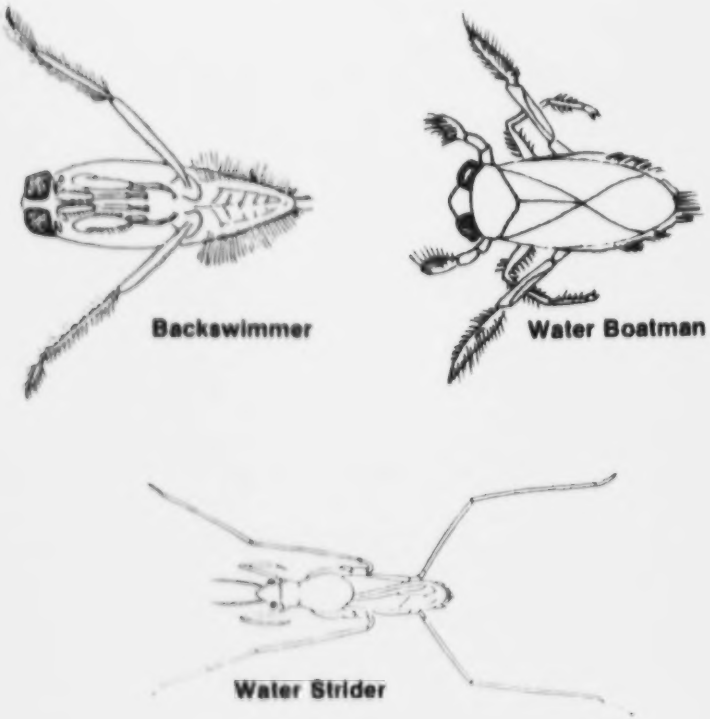


Figure 18.

Alderflies, Dobsonflies and Fishflies (Order Megaloptera)

- These aquatic insects are quite striking while in the larval stage. The larvae of the dobsonflies are called hellgrammites and are known far and wide as a fine fish bait. They are most often found crawling on the bottom or buried in the mud of lakes and wetlands. As their fierce appearance would suggest, they are predatory.

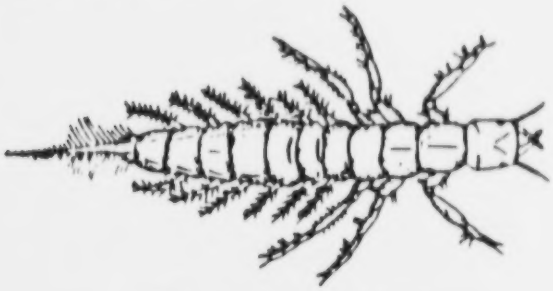


Figure 19. Fishfly Larva

Caddisflies (Order Trichoptera)

- These insects have "camouflaged" aquatic larvae. The best way to find them is to look on the bottom of shallow water for a moving piece of debris. Many caddisfly larvae build hollow cylindrical cases composed of grains of sand, small pieces of leaves, grass, bark and twigs. Stream-living caddisfly larvae usually use heavier sand for their cases, while our lake and wetland species are more apt to build larger, leaf or twig cases. They are a pollution-sensitive group.

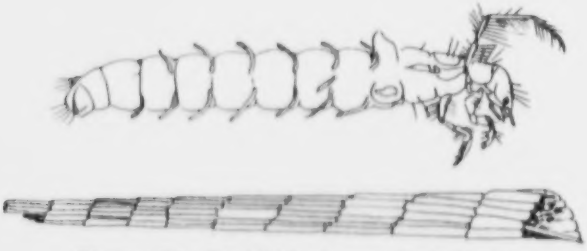


Figure 20. Caddisfly Larva And Case.

Beetles (Order Coleoptera)

- Beetles comprise the largest order of insects, with approximately 5000 members in the aquatic environment. Some adult aquatic beetles rely on atmospheric oxygen to breathe. They either store air under their wing covers, or capture air bubbles on the fine hairs that cover their legs and stomach area. Adults are usually located in shallow areas on vegetation or debris. One of the most visible beetles on the surface of lakes and wetlands can be seen swimming around helter-skelter in circular motions. This is the whirly-gig beetle. If you catch one, smell it; it has an apple-like odor. Beetle larvae are totally different from the adults in their appearance, as shown in the illustration below. In general, adult beetles are tolerant of a wide variety of pollutants. However, the larvae have more critical water quality requirements.

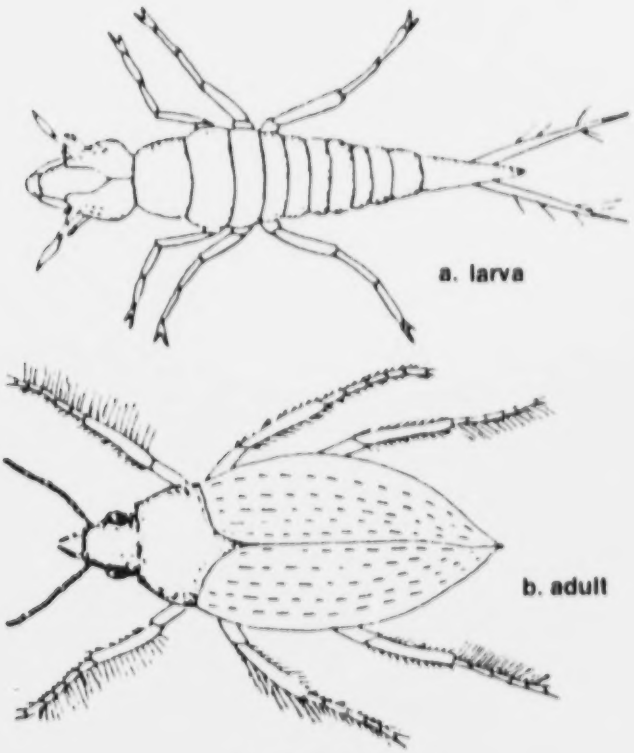


Figure 21. Beetles

Midges and Flies (Order Diptera)

• Although these insects spend their immature stages in water, the adults are terrestrial. Larvae of this group inhabit every type of freshwater environment. They have an elongated, wormlike body and no true legs. Coloration will vary from black and brown to red, white and yellow. Some of the more noticeable dipterans are the deer flies, mosquitoes and midges. Mosquito larvae hang from the water surface where they breathe through tubes, although they will dive when disturbed. Midge larvae remain on the bottom during the day, but some species forage through the water at night. They can be unbelievably abundant. Over 50,000 individuals per square meter have been found on the bottom of some lakes. Many species are tolerant of a wide variety of pollutants, while others are intolerant.

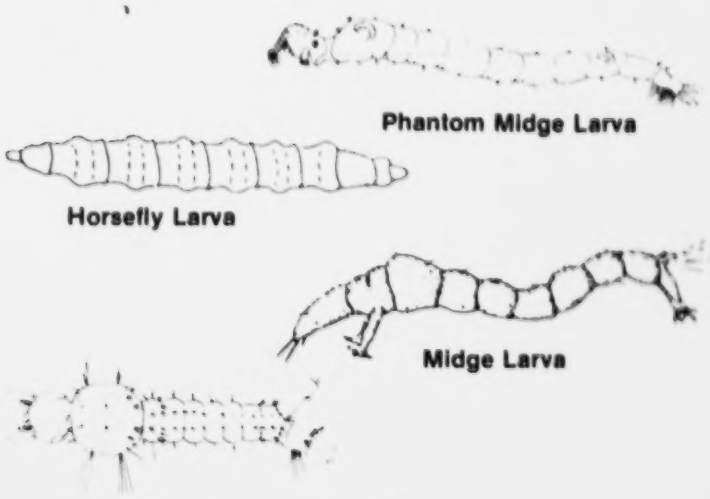


Figure 22. Flies

These are only a few of the many interesting macroinvertebrates in our Kentucky lakes and wetlands. If you would like to learn more about these organisms, consult the Reference Section. A simplified key for macroinvertebrates has been provided in Appendix III. Enjoy your ventures into this little-known world.

Aquatic Plants

Many of the benefits listed for wetlands, such as filtering pollutants, controlling floods and erosion, providing fish and wildlife habitat and high productivity are directly related to the vegetation. The variety, quantity and overall health of the plant community will usually determine how efficient a wetland will be for perfoming these functions. In most cases, in both lakes and wetlands, a diversity of plant types is best. Trees and shrubs provide shade and stability and absorb some excess nutrients through their roots. Emergent plants (those found growing at the water's edge or slightly in the water) provide sediment traps and bank stability. Floating-leaved plants (rooted in the bottom of shallow water areas) help absorb excess nutrients from the water and stabilize bottom areas, as do submerged plants (similarly rooted but with no parts above the water). Free-floating plants also absorb nutrients. All plant types provide food and cover for insects, fish and wildlife. The plants listed here are a few of the more common members of each of the above types.

Green and Bluegreen Algae

- These are microscopic plants suspended in waters of ponds, lakes or wetlands that provide the basis of the food chain. As mentioned earlier (see cultural eutrophication), some species may become so abundant they impart a "pea soup" green or brownish color to the water. A few types form a scum-film on the surface. Others may become dense enough to form mats covering the entire water surface. Such mats may interfere with irrigation, livestock watering, boating, swimming and fishing. Natural die-off of the plants may deplete the dissolved oxygen in the water, causing fish kills, and may cause taste and odor problems in public water supplies. Some species will release toxins into the water which may sicken or kill livestock.

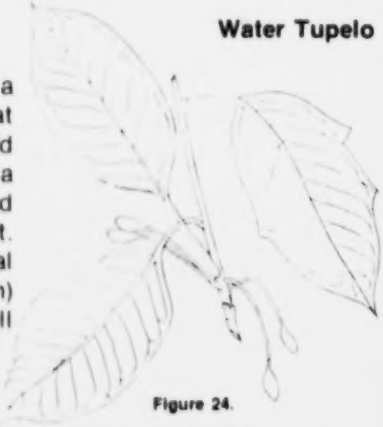
Bald Cypress
Figure 23.

Bald Cypress *(Taxodium distichum)*

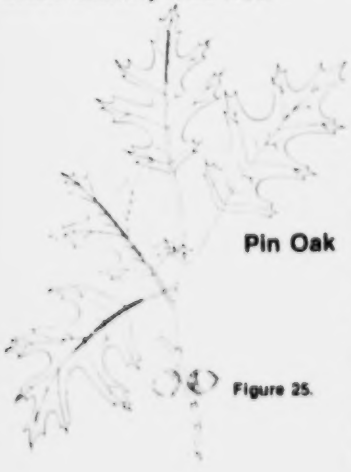
• This is a unique tree in that, unlike other coniferous (cone-bearing) types such as pine trees, it drops its leaves in the fall. You can find this tall (up to 125 feet) tree growing in waist-deep water of western Kentucky forested wetlands. It has narrow, light green, feathery leaves; fibrous, shredding bark; and a trunk that is typically swollen (buttressed) at the base. The roots often have projections (called cypress knees) sticking out of the water.

Water Tupelo *(Nyssa aquatica)*

• The water tupelo also has a buttressed base (a sign of trees that spend much of their lives in water) and is found in forested wetlands. It is a deciduous (sheds its leaves) hardwood tree that may reach 80 feet in height. The leaves are 5-6 inches long and oval to oblong in shape. The small (1 inch) green fruits found lying beneath it will often identify this tree.



Water Tupelo
Figure 24.



Pin Oak
Figure 25.

Pin Oak *(Quercus palustris)*

• Although the pin oak is found growing throughout Kentucky and in virtually all types of habitats, its native or natural home is in poorly drained or wet soils such as those found in bottomland hardwood forests. It may grow 80 feet tall and has a pyramid shape. The leaves are 3-6 inches long, have five to seven pointed lobes and are a shiny green. This oak can be distinguished by the downward angle of its lower limbs.

Buttonbush *(Cephalanthus occidentalis)*

• This shrub commonly occurs in scrub/shrub and forested wetlands, shallow areas of ponds and lakes and sluggish streams throughout Kentucky. It is 5-8 feet tall, has 2½-5 inch long oblong leaves and reddish twigs. It can be easily spotted in July when the ¾ inch, white, spherical flowers are blooming. These small "balls" remain on the plant until Autumn, turning from green to brown.

Buttonbush

Figure 26.

Cat-Tail

Figure 27.

Cat-tail *(Typha latifolia)*

• This common emergent plant can be found growing in most wetland areas in Kentucky, including lake borders. The brown "tail" is actually composed of thousands of tiny flowers. In Autumn these flowers begin to drop or blow away, appearing like cotton in the wind. The cat-tail grows 3-6 feet tall with thick, narrow leaves equally as long.

Arrowhead *(Sagittaria latifolia)*

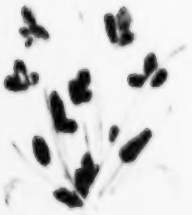
• The arrowhead got its name from the shape of its 6-12 inch long leaves. The white flowers appear in July and are 1-1¼ inches wide. They form along a long stalk originating near the base. This is another emergent plant common to wetlands and to lake and pond margins throughout Kentucky.

Arrowhead

Figure 28.

Sedge (Family Cyperaceae)

• This is a very large group of emergent wetlands plants with hundreds of varieties found along the edges of Kentucky waters. Usually they are mistakenly called grasses. Sedges differ from grasses in that their stems are solid (not hollow like grasses) and may be triangular, and in that their leaves typically wrap around the stem at their base. Sedges are great bank stabilizers and erosion fighters. Two varieties commonly seen in Kentucky are listed below.



Nutsedge

Nutsedge *(Cyperus strigosus)*

• This sedge has a triangular stem 6-20 inches high with grass-like leaves and a cluster of tiny, flat, flowers at the top. Close examination of the flowers will reveal hundreds of minute seeds. Nutsedges will occur as individual plants scattered in wet soils.

Figure 29.

Bulrush

Bulrush *(Scirpus validus)*

• This sedge has a round, pulpy stem 3-5 feet tall. Its only leaves are short and at the top of the plant. The flowers appear in tiny clusters on short stalks from the top of this sedge. They change from green to brown as the season progresses. Bulrushes typically grow in tight groups, with several stems occurring in a square foot area.

Figure 30.

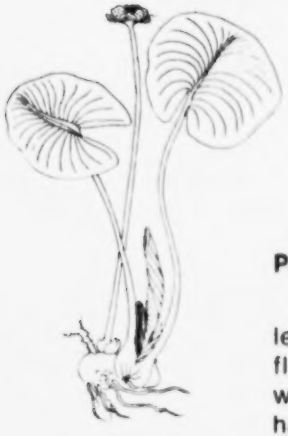


Figure 31.

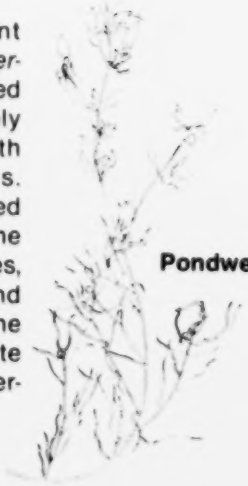
Pond Lily

Pond Lily *(Nuphar advena)*

- The large, 4-12 inch, waxy leaves of the pond lily can be seen floating in shallow, pooled or sluggish waters in many areas of Kentucky. It has large, 1¼-2 inch, yellow flowers on a separate stalk that are generally held up out of the water. A closer look will show that the pond lily is well rooted in the substrate.

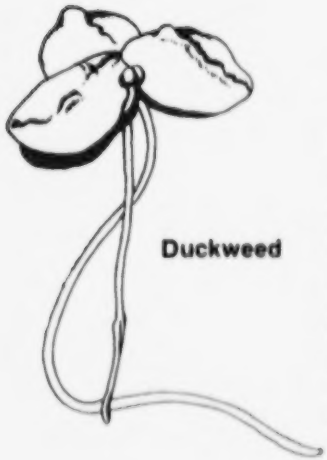
Pondweed *(Potamogeton* species)

- There are many different types of pondweeds (the species *diversifolius* is illustrated), but all are rooted in the substrate. Some are entirely submerged, while others have both floating and submerged leaves. Typically, these plants occur in pooled or sluggish waters throughout the state. They may, in local ponds or lakes, cause a problem to swimmers and boaters with their dense growth. The slender, limp stems can grow quite long and have thin, linear leaves underwater and oval floating leaves.



Pondweed

Figure 32.



Duckweed

Duckweed *(Lemna minor)*

- These tiny floating plants (about ¼ inch) can cover a pool so well that no light can reach the water beneath them. This lack of sunlight will stop the photosynthesis of other water plants that supply oxygen for most aquatic life in these types of waters. This will result in a very low variety of fish and insects. Duckweed got its name from the ducks which eat it and carry it on their feathers from one body of water to another. It is easy to see why duckweed can be found in so many places.

Water Nymph (Naid)

Naid *(Najas minor)*

- This plant is not native to Kentucky. It was introduced years ago and can now be found submerged in shallow, sluggish waters in many parts of the state. It, too, is a favorite duck food. The naid is a slender, limp plant with linear leaves (less than ¼ inch wide) and long stems well rooted in the substrate. When found growing in dense mats, it can be a nuisance to swimmers and boaters. Another common name for the naid is the water-nymph.

Figure 34.

Coontail

Figure 35.

Coontail *(Ceratophyllum demersum)*

• The coontail is another submerged plant that commonly occurs in Kentucky's shallow, sluggish waters. It may have stems 7 feet long but less than 1 inch wide. The leaves look more like thin, feathery roots with tiny barbs. This plant, though limp and delicate, may grow in nuisance quantities.

Water Milfoil *(Myriophyllum spicatum)*

• Water milfoil is a very slender, submerged plant with many branches. It can grow in such dense stands that it chokes out other plants. The water milfoil is another non-native plant that is fairly common in shallow, sluggish Kentucky waters. Although similar in appearance to the coontail, this plant does not have any teeth or barbs on the feathery leaves, and so lacks the rough, textured feel.

CHAPTER 3

SURVEYING LAKES AND WETLANDS

Before undertaking a lake or wetland survey, your group should first determine long and short term goals and become familiar with the area under consideration. Begin by acquiring maps of nearby watersheds. United States Geological Survey (USGS) maps are very useful for learning the characteristics of a drainage basin. There are two types of USGS maps that may prove helpful. The 7.5 minute series topographic maps show topography, roads, towns, streams, some wetlands, ponds and lakes, oil wells, mines and a variety of additional information. Geological quadrangle maps provide some of the information listed above and give a detailed picture of the geology of the watershed. County road maps, available from the Kentucky Transportation Cabinet, may also be valuable. All of these maps will be useful in locating sampling areas and access points, and may provide historical watershed information. Try to get a feel for the land-use characteristics of the area surrounding your adopted lake or wetland, including agricultural, mining, residential, conservation and other uses. Knowing the surrounding lands leads to a better understanding of the factors that affect the aquatic health of your adopted body of water.

Once you have a general understanding of the watersheds of your area, choose the lake or wetland to be monitored. Remember not to tackle too large a project. If you really want to study a large expanse of water, perhaps you can coordinate with another WATER WATCH group. Keep in mind that the larger the adopted area, the more work there will be and some group members may loose interest. An important goal of this program is for your group to enjoy learning about the world of lakes and wetlands. Choosing the right area size for your group will provide a more satisfying level of understanding and can be more effective in protecting your selected water resource.

When choosing a study area, locate one that is accessible. Consider the land you must cross, the descent to the lake or

wetland and the water depth. If you must traverse private lands, get in touch with the owners for permission. It is very possible that you may arouse their curiosity and they may wish to help. However, if trouble arises, try and find another site.

Prior to sampling, the study group may wish to contact departments within federal, state and local governments, as well as regional universities, to see what information is available on the adopted lake or wetland. Federal, state and local organizations that may have pertinent information are listed in the Agency Assistance Section of your WATER WATCH Program manual.

As a suggestion, before any decision is made regarding the type of techniques you will use to monitor your watershed, introduce your group to the lake or wetland by conducting a loosely structured hike along its banks. This should be a group affair. Present background information so that everyone is aware of the group's goals. Encourage city planners, wildlife biologists or anyone else who might have expertise on your adopted water body to help conduct the first walk. They may have a great deal of information and experience to share. This is the opportunity to address the lake's or wetland's historical importance, its ecology, possible problems and the individual interest each person has in the adopted area. Walk along the banks pointing out attributes, past uses and problems. Just have a general "gab session" about your lake or wetland. Upon returning, exchange ideas on what you have seen. After your first walk, you will probably be ready to decide what activities your group should begin planning for your adopted resource.

Choosing a Survey

The objectives of lake and wetland studies may be either aesthetically or scientifically oriented or both. However, two objectives of surveying a lake or wetland shoud be to (1) determine ambient (present day) characteristics (biological, physical and/or chemical), and (2) monitor the lake or wetland over time to determine if it is improving, remaining the same or degrading. There are three basic types of surveys that can be used: 1) the visual survey, 2) the physical/chemical survey, and 3) the biological survey.

The Visual Survey

The visual survey is the simplest of the survey types, and a great deal of information about the adopted lake or wetland can be learned if it is properly conducted. This survey requires very little equipment; basically you'll need a clip board, pencils, data sheets (Appendix II), field guides and maps. Hip boots and a camera, if available, are helpful. For safety reasons, the visual survey should be conducted by more than one individual. Besides, two or more people will do a better job describing the characteristics of the adopted area. You might also want to take a thermometer, pH paper, diagnostic tables (Appendix I) and binoculars.

During the initial visual survey, the participants should draw a map of that portion of the lake or wetland to be surveyed. The map does not have to be a perfect likeness of the area, but it should include the major habitat types, locations of discharge pipes, dumps, etc. Notes should be made on the data sheet regarding size of the area surveyed, bottom types, types of riparian (shoreline) vegetation, adjacent land uses, and unusual lake or wetland odors and colors. A camera is useful in documenting the various natural or unnatural lake or wetland characteristics listed above. Be sure to label all pictures with the proper location, date, time and photographers' names. It may be helpful to have photographic stations where pictures are taken at various times of the year and over a period of several years. These will make slowly-occurring changes more evident.

If some of your group members have boats, you may want to conduct your visual survey with some people walking the shoreline while others follow along in the boats. This will provide more information on the extent of shallow areas and vegetation. If the boat has a depth-finder (fish finder), you can prepare a bottom-depth map of the lake or wetland.

The Physical/Chemical Survey

The techniques required to conduct physical/chemical (and biological) surveys in lakes may differ from those used in wetlands. Lakes, because of their size and depth, may be sampled at different depths and in different zones. Since wetlands are often shallow, sampling at different depths may not be necessary or possible.

The physical/chemical survey is designed to delineate some of the basic physical and chemical characteristics of your lake or wetland. Physical features include temperature, visibility (turbidity), and color, while chemical attributes include dissolved oxygen, conductance, hardness, pH, and a multitude of other characteristics. Most chemical analyses require laboratory capability, so we won't discuss them in this handbook. However, relatively inexpensive and easily operated field kits are commercially available and if your group decides it wants more detailed information on its adopted lake or wetland, the Division of Water will be glad to help. Regardless of the kind of physical/chemical data collected, over a period of time they will allow you to see changes in the water quality of your lake or wetland. Always record the date, time, location and your name along with the other data.

Some physical/chemical analyses can be done easily and inexpensively. Three of these are pH, temperature and visibility. **pH** is a measure of the acidity or alkalinity of the water. The lower the pH, the more acid the water. A pH of seven indicates that the water is "neutral" (i.e., neither acid nor alkaline). Most natural water has a pH in the range of 6 to 9. Anything above or below this range may indicate a problem. Approximate pH can be determined by using pH paper that is available at many drugstores

Visibility is measured with a simple instrument called a **Secchi disc** and is a measure of the depth to which one can see into the water. Easily constructed and weighted, the disc is 20 cm. in diameter (8 inches), with the surface painted in opposing black and white quarters (see Figure 37). A ring at its center is attached to a line marked at six-inch intervals so that when the disc is held by the line, it hangs horizontally. To determine Secchi disc visibility, slowly lower the disc into the water until it disappears, and note this depth. Lower the disc a few more feet and slowly raise it until it reappears; note this depth. The average of the two readings is the Secchi disc visibility depth. This value can be used to compare visibility of different regions of your lake or wetland and to compare visibility at different times of the year. Since clearness of the day, time of day and roughness of the water all affect the reading, be sure to record these data along with the visibility depth.

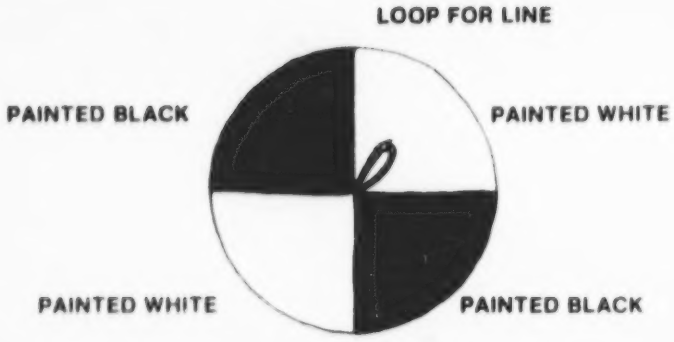


Figure 37. Secchi Disk.

Figure 38. Water Sampler.

Temperature is easy to measure in shallow water, but deep lakes present more of a problem. An inexpensive thermometer designed to take temperatures at various depths can be purchased at some sporting goods stores. If you can't obtain one of these, water samples can be taken from a boat at different depths using the simple apparatus pictured in Figure 38. This water sampler will allow you to measure the temperature profile of a stratified lake as described in Chapter 1. Simply stopper the bottle, lower it to the desired depth (every two feet until below the thermocline) and give a sharp tug on the line. The bottle will fill with water from that depth. Rapidly bring it to the surface and measure the temperature below the neck of the bottle. Obviously, the Secchi disc and water sampler are designed to be lowered from a boat.

The Biological Survey

An analysis of aquatic organisms provides valuable water quality information. Chemical and physical measurements generally catch only one moment of a lake or wetland's history of the water body. Aquatic invertebrates have proven to be excellent organisms for water quality analysis. Basically, they are stationary residents traveling only short distances. For this reason, and the fact that they have life spans that generally last at least a year, the investigator observing the numbers and types of aquatic invertebrates may be able to gain a general insight into the past year's water quality events and deduce environmental impacts.

Surveying Macroinvertebrates

Most macroinvertebrates are smaller than a half dollar. They will have an incredible array of colors and intriguing shapes. You'll find yourselves comparing finds, examining their respective habitats, and wondering about the purposes of their contrasting features.

Many macroinvertebrates can be seen on the surface or swimming in the water. These can be easily scooped up in a dip net and examined. The rest of the invertebrates are more difficult to find, especially in the daytime. Often they hide on or under aquatic vegetation. You can find many of them by turning over floating leaves like the lily pads or by closely examining the stems and bodies of emergent and submerged plants. In some cases, you may have to pull up some vegetation mats and rinse them off over a white pan or cloth. You

will be amazed at the variety and numbers of organisms found by this method.

Benthic (bottom-living) macroinvertebrates are especially adept at hiding, but you will find many of them under logs or stones in shallow water. You also can scoop up bottom mud (sediments) in a seive, swish it through the water to remove most of the mud, and examine the remaining debris in the white pan. Deep water sediments can be sampled by lowering a dredge from a boat, but this is a difficult and sometimes dangerous task.

As with all biological surveys, whenever possible return your specimens to the water in good shape. This is especially true of threatened and endangered species. There are endangered plants and animals in many wetlands. If you find one, DO NOT COLLECT IT. The Kentucky Nature Preserves Commission would be happy to hear about your find, and might even send someone to photograph it.

Count and record the total numbers of your specimens and separate them into look-alike groups based on body shape and number of legs and tails. Since members of the same group vary greatly in size and color, these are not good characteristics upon which to categorize them. Total numbers of individuals, numbers of kinds, and numbers of individuals per kind are all important in judging the quality of your water body (see Appendix I). In order to identify your groups, you may want to use the key provided in Appendix III.

Surveying Vertebrates

Vertebrates are animals with backbones. They include fish, amphibians (salamanders, frogs, toads, and sirens), reptiles (snakes, lizards and turtles), birds and mammals. You should keep field notes of the numbers and kinds of vertebrates you observe. Identification manuals are listed in the Reference Section.

You can learn a lot about the fish population of your lake or wetland by talking to fishermen. Very often they know more about the fish of your water body than anyone else. Be courteous when asking them for information. If they are willing to talk with you, ask what they most often catch, what other fish they know are in the lake or wetland (especially non-game species), and what changes they have seen in the fish populations over the last few years.

Reptiles and amphibians (collectively called "herptiles" or just "herps") should be noted when seen and also when heard. Most frogs and toads have characteristic calls and can be identified by listening for them on a warm Spring or early Summer evening. There are even records of frog calls available from Cornell University so you can learn the various songs.

Birds, of course, are highly visible and interesting to many people. The Kentucky Department of Fish and Wildlife Resources and the Kentucky Nature Preserves Commission are currently compiling a Breeding Bird Atlas for Kentucky and will be happy to receive records of the birds breeding around your lake or in your wetland. These agencies will also provide reporting forms to your group. Birds, like frogs, can be identified by songs or calls and bird song records are available from several sources.

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APPENDICIES

APPENDIX I DIAGNOSIS

How can you tell what might be wrong with your lake or wetland? Just like diagnosing the cause of a pet's sickness, you can take all the symptoms and signs together and try to determine what might be causing the problem. The following tables are designed to help you know the types of problems that might occur in your area and the obvious signs of those problems. Read each table several times, allowing yourself to get a feel for threats to lakes or wetlands. You may want to take these tables with you when you next visit your adopted area.

Table 1. Land-use Indicators of Water Pollution Possibilities.

Woodland: Check for sedimentation (cloudy or muddy water) from erosion caused by logging, road building or mining.

Farmland (crops, pasture and feedlots): Check for excessive algal growth (green water or a lake or wetland clogged with water plants) caused by fertilizers or manure draining into the lake or wetland. Also watch for sedimentation from farming practices.

Cities and Towns: Urban storm sewer runoff can carry with it all sorts of pollution including metals (such as lead), salts, chemicals and oil. Insect and fish counts may indicate the presence of one of the above, but chemical analysis of the water may be needed to pinpoint the cause.

Industries: Keep an eye out for color changes, excessive algae, odor, absence of animal life such as insects and fish, and fish kills. If these occur, the lake or wetland should be tested for inorganic (metals), organic (pesticides, phenols, oil, etc.), and toxic substances.

Sewage (treatment plants or pipelines): Look for "organic" pollution indicated by excessive algal growth, white foam or suds from detergents, sludge beds, absence of some species of fish and insects, and/or extreme abundance of others (see Tables 3 and 4).

Mining: Check for sedimentation and acid drainage. Acid drainage can be detected by a low pH (pH less than 4.0). A yellowish-orange deposit often is present on the bottom due

to high iron content of most mine drainage. Oftentimes, waters with an extremely low pH will be exceptionally clear.

Construction: Land-disturbing activities such as development and road building are a leading cause of erosion and sedimentation, so watch for cloudy or muddy water.

Residential: Lawn fertilizers, detergents used for washing clothes or cars, oil drained from autos, septic tank outflow, and general trash (cans, bottles, etc.) are common forms of residential pollution. Keep an eye open for excessive algae growth, white suds, color sheen on the water surface or bank (oil), or absence of organisms.

Table 2. Physical Indicators of Water Pollution

A. Color of Lakes or Wetlands

Green: If the lake or wetland is noticeably green, this could be an indication of "organic" pollution being released into the lake or wetland feeding algae (hense the term algal bloom) and other aquatic plants.

What to do: Check streams that discharge to the lake or wetland for possible sewage, fertilizer (including lawn fertilizer) or livestock runoff areas.

Orange-Red: Orange to red deposits on lake or wetland bottoms could be caused by acid mine drainage or oil well runoff. The color is due to an iron compound in such areas.

What to do: Check for drainage from mining, drilling or industry.

Light Brown: Sediment deposits (muddy or cloudy) caused by erosion.

What to do: Search the watershed for disturbed ground left open to rainfall and subsequent erosion.

Multi-color Reflection: Indicates oil floating on the lake or wetland.

What to do: Check the watershed closely for the source. Waste oil may have been dumped into or beside

the lake or wetland by an individual or service station. Overflow may have occured from an oil well operation.

White Deposits Along Banks: White, crusty deposits along the edge of the lake or wetland may indicate salt (brine) pollution from oil well operations.

What to do: Search the watershed for improperly operated oil wells.

Dark Reds, Purple, Blues, Blacks: Indicates organic dye pollution from leather tanning or clothing manufacture.

What to do: Check the watershed closely for the source. It probably enters the watershed through a discharge pipe from an industrial operation.

B. Odor of Lakes or Wetlands

Rotten Egg Odor: May indicate sewage pollution.

Musky Odor: May indicate presence of untreated washwater, sewage or livestock waste, decaying algae or other conditions.

Acrid Smell: May indicate presence of industrial or pesticide pollution.

Chlorine: May mean that a sewage treatment plant or chemical industry is over-chlorinating their effluent.

Foaming (Suds): When white, and greater than 3 inches high, foam generally is due to detergents.

What to do: Check the watershed for industrial, municipal, residential, or agricultural waste.

Table 3. Fish as Biological Indicators of Water Quality.

A. Erratic Swimming

Fish swimming near the surface, gasping for air at the surface, or swimming in circles may indicate the presence of a toxic substance.

B. Disease

Red sores or white cottony-like places on fish indicate the presence of disease. Several diseased fish in an area may indicate the presence of toxic substances at levels not great enough to immediately kill the fish.

C. Absence of Fish

This may be a strong indication of a badly stressed lake or wetland. The cause could be urban runoff, or sewage or toxics (organic or inorganic) entering the lake or wetland.

What to do for A-C: Chemical analysis of the water may be needed to find the source, but check the watershed to see where the problem begins.

Table 4. Aquatic Macroinvertebrates as Biological Indicators of Water Quality.

A. Great variety of macroinvertebrates with few of each kind: Clean water.

B. Less variety, but greater abundance of each kind: Water is overly enriched with organic matter (nutrients from agricultural runoff, sewage runoff).

C. Only one or two kinds of macroinvertebrates, with great abundance: Severe organic pollution.

D. Few or no macroinvertebrates, but the lake or wetland appears clean: Toxic pollution.

What to do for B-D: Check the watershed for potential sources of pollution. A chemical analysis may be needed to pinpoint the pollutant(s) causing the problem(s).

Appendix II

Survey Data Sheet

Name of Lake or Wetland

Surveyors' names

Survey Site Location

Date

Weather Conditions: ☐ Clear ☐ Cloudy ☐ Rain

☐ Other _____

Visual Survey Data:

Water appearance:
- ☐ Scum
- ☐ Foam
- ☐ Muddy
- ☐ Milky
- ☐ Clear
- ☐ Colored sheen (oily)
- ☐ Brownish
- ☐ Reds, Purples, Blues, Black
- ☐ Other

Bottom coating:
- ☐ Orange to red
- ☐ Yellowish
- ☐ Black
- ☐ Brown
- ☐ White deposits along bank
- ☐ Other
- ☐ None

Odor:
- ☐ Rotten Egg
- ☐ Musky
- ☐ Acrid
- ☐ Chlorine
- ☐ Other
- ☐ None

Plant Covering in littoral zone:
- ☐ less than 30%
- ☐ 30% - 70%
- ☐ 70& - 100%

Plant Covering on shoreline:

Trees (%) _____
Shrubs (%) _____
Grass (%) _____
Rushes sedges, etc. (%) _____
Exposed (%) _____
Other (%) _____

Land Uses of the Watershed

Agricultural (%)
Pasture _____
Crops _____
Other _____

Urban (number)
Homes _____
Factories _____
Stores _____
Other _____

Mining (number):
Surface _____
Deep _____
% land area covered _____

Forestry:
% land area forested _____
number active logging sites _____

Construction:
number of active sites _____

Survey Data Sheet - (continued)

Water Uses:

		Recreation:	
Drinking Water Withdrawal	____	Swimming	____
Industrial Water Withdrawal	____	Fishing	____
Agricultural Water Withdrawal	____	Boating	____
Irrigation	____	Other	____
Livestock Water	____		

List number of dams, piers, entry ramps, shoreline erosion control structures, etc.:

_____

_____

Litter: Estimate extent/numbers of paper, small trash, cans and bottles, tires, cars, etc.:

_____

_____

Physical/Chemical Survey Data:

Water Depth _____

Temperature: (Give values for air and surface of water, and list other values by depth.)

_____

_____

Secchi disc visibility depth: _____

pH:

Surface: _____ Other depths: _____

Biological Survey Data:

List major types of plants and the percentage of total plants that each makes up:

_____

_____

_____

_____

_____

Survey Data Sheet - (continued)

Macroinvertebrates:

Total number of individuals: _____

Total number of kinds: _____

List kinds found, with numbers of each kind in parentheses:

_____

_____

_____

_____

Vertebrates: List kinds and numbers of fish, amphibians, reptiles, birds, or mammals observed:

_____

_____

_____

_____

Additional comments needed to describe the lake or wetland (continue on other side if necessary):

_____

_____

_____

_____

_____

APPENDIX III
KEY TO BENTHIC MACROINVERTEBRATES

The following key is a general guide to the orders of benthic macroinvertebrates found in Kentucky waters. To some, the key may appear complicated; however, when you understand how it works, it is quite simple. When reading the key, you will make a series of choices that will correctly match the observable traits of the invertebrate. You will be given two or three alternatives and will choose the one that applies to the particular animal. Then proceed as directed by using the numbers at the end of the sentences to find the next set of alternatives or until an end point is reached. At the end point, you will identify the order of your animal in question.

This key, modified from Standard Methods, may or may not be used with the discussion on benthic macroinvertebrates. It is more extensive than you will need. For example, less common animals that we did not discuss are included. Practice with the key. Do not let it overwhelm you. It is provided here as an extra help to identifying "bugs" that puzzle you. The Reference Section lists other sources of help.

1a. Body with right and left sides, but may be superficially coiled into a spiral; animal usually not attached but may live inside an attached cocoon or case, or crawl about; usually solitary **4**

1b. Body with no obvious right and left sides **2**

2a. Body radiating out from a central point; bodies soft and smooth; tentacles around a mouth; no anus. HYDRAS and JELLYFISHES (Coelenterata), not illustrated ..... *

2b. Body or colony nonsymmetrical **3**

3a. Body mass generally porous; not a colony. Freshwater representatives generally are fragile, colored green or brown. SPONGES (Porifera), not illustrated ..... *

3b. Colony a jelly-like mass. MOSS ANIMALS (Bryozoa), not illustrated ..... *

4a. Animal living within a hard limy shell, soft body (Mollusca) **10**

4b. Animal without a limy shell **5**

5a. Jointed legs present, may not be functional. Body may be hard or soft. **11**

5b. Jointed legs absent, body covering mostly soft, animal pliable (a hardened head capsule may be present) **6**

6a. Body banded by rings or creases at regular intervals, dividing it into many small segments much wider than long **7**

6b. Segments present or absent; if present, not much wider than they are long **8**

7a. Body with suction disc at one or both ends, in length usually less than 10 times its width. LEECHES (Annelida, Hirudinea) . . . . . *

7b. Body without suction discs, in length usually more than 10 times its width; hairs or bristles often evident. SEGMENTED WORMS (Annelida), not illustrated . . . . . *

8a. Body unsegmented, long and slender, appearing smooth, evenly tapered to a fine point at one end. ROUNDWORM (Nematoda), not illustrated . . . . . *

8b. Body otherwise **9**

9a. Body flat, elongate, or oblong; unsegmented head is spade-shaped. Pigmented spots on top of head often give the animal a cross-eyed appearance. FLATWORMS (Turbellaria), not illustrated . . . . . *

9b. Body segmented, cylindrical, oblong, or capsule-like; may or may not have a head capsule and thick fleshy knobs on underside. Larvae of MIDGES and FLIES (Diptera) . . . . . *

10a. Shell consisting of two hinged halves. BIVALVES (Pelecypoda) . . . . . *

10b. Shell entire, usually spiral but may be "coolie hat" shaped. SNAILS (Gastropoda) . . . . . *

11a. Body with functional legs **12**

11b. Body without functional legs, mummy-or capsule-like, living in a cocoon. PUPAE (Insecta) . . . . . *

12a. Body with three pairs of legs. Larvae, nymphs, and some adults (Insecta) **16**

12b. Body compact, spider-like, with four conspicuous pairs of legs (two other pairs of appendages present). WATER MITES (Acari), not illustrated . . . . . *

12c. Body with at least five conspicuous pairs of legs. CRUSTACEANS (Crustacea) **13**

Key to Crustaceans

13a. Sides of body compressed **14**

13b. Body flattened horizontally; body with three or more joints. SOWBUGS (Isopoda) . . . . . *

14a. Eyes on stalks **15**

14b. Eyes, if present, only seen as spots on sides of head. SCUDS (Amphipoda) . . . . . *

15a. Pincers on first pair of legs strong and large; other legs stout, cylindrical, and used for walking. CRAYFISH, also marine lobster (Decapoda) . . . . . *

15b. Pincers on first pair of legs weak and small; other legs, thin and flattened, are used for swimming. SHRIMPS (Mysidea and others) . . . . . *

15c. No obvious pincers on first pair of legs. FAIRY SHRIMP and allies (Eubranchiopoda) . . . . . *

Key to Insect Larvae, Nymphs, and Some Adults

16a. Animal flea-like, with a forked projecting appendage on the underside. SPRINGTAILS (Collembola), not illustrated . . . . . *

16b. Animal otherwise **17**

17a. Body ending in long segmented filaments **18**

17b. Long filaments absent, or if present, not segmented **19**

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18a. Two tail filaments, legs ending in two claws. STONEFLIES (Plecoptera), not illustrated .....*

18b. Three tail filaments (with few exceptions); middle filament may be slightly smaller than laterals, legs ending in one claw. MAYFLIES (Ephemeroptera).....*

19a. Back of body covered with hard wing covers, a pair of thin, sheet-like wings underneath the covers. ADULT BEETLES (Coleoptera) .....*

19b. Back without hard wing covers.....**20**

20a. Body with exposed membranous wing pads on back **21**

20b. Body without membranous wings or wing pads (larvae) **23**

21a. Membranous wings present; held flat and in a V-shape on back. Mouth parts formed into a long, sharply pointed beak folded underneath body. TRUE BUGS (Hemiptera) .....*

21b. Membranous wings absent, wing pads present. Mouth parts formed into an extendable, scoop-like mask that covers face. (Odonata: Damselflies and Dragonflies) **22**

22a. Body ending in three oblong, fan-like plates. DAMSELFLY LARVAE (Zygoptera) .....*

22b. Fan-like plates absent. DRAGONFLY LARVAE (Anisoptera) .....*

23a. Mouth parts formed into slender curved rods nearly half as long as body (less than 10 mm). SPONGILLA FLIES (Neuroptera), not illustrated .....*

23b. Mouth parts adapted for biting or chewing **24**

24a. Body with five paired knobs on underside of abdominal segments, legs on first three segments short and stuffy. Often found on lily pads. AQUATIC MOTH LARVAE (Lepidoptera), not illustrated .....*

24b. Body without paired knobs on underside of abdomen **25**

25a. Sides of each abdominal segment with a slender, tapering process **26**

25b. Sides of each abdominal segment without a tapering process, but may have hair-like or tubular processes **27**

26a. Body ending in a pair of hook-bearing fleshy legs or in a single tapering filament. HELLGRAMMITES and relatives (Megaloptera) ..... *

26b. Body otherwise. BEETLES (Coleoptera) ..... *

27a. Body covering mostly hard; knobs, hair-like processes, or other special ornamentation may be present on back, or else body is entirely soft except for a hardened head capsule. BEETLES (Coleoptera) ..... *

27b. Most of body soft except for a hardened head capsule and with one to three hard plates on the back of first body segments; tubular processes may be present on sides of the body in various arrangements. Body may end in a pair of hook-bearing legs. Most larvae living in portable cases made of bits of sticks, leaves, or sand or in attached fibrous cases. CADDISFLIES (Trichoptera) ..... *

GLOSSARY

A

acid mine drainage: water that has become acidic by flowing over or through mine wastes. Can affect either surface water or groundwater.

acrid: sharp, stinging, irritating.

acute toxicity: any poisonous effect, produced by a single short-term exposure, that results in severe biological harm or death.

algae: simple plants which do not grow true roots, stems, and leaves and which live mainly in water; provides food for the food chain.

aquifer: an underground bed or layer of earth, gravel, or porous stone that contains water.

B

bacteria: single-celled microorganisms that lack chlorophyll.

benthic region: the bottom of a body of water.

benthos: the animals and plants that inhabit the bottom of a water body.

bioaccumulation: the process whereby a substance becomes concentrated by the biological organisms that consume it.

bivalve: a class of animals having two shells hinged together. Clams and mussels are examples.

bloom: a proliferation of algae and/or higher aquatic plants in a body of water, often related to pollution.

bottomland hardwoods: a type of forested wetland, common in western Kentucky, containing such valuable hardwood trees as gum, cypress, oak and water hickory. Very productive fish and wildlife habitat.

brine: the salt-laden water produced during oil and gas extraction.

C

carnivorous: meat-eating.

channelization: the modification of a stream, including the straightening of stream meanders, in an attempt to control floods, and improve navigation.

chronic toxicity: long-term effects that may include changes in appetite, growth, metabolism, reproduction, and even death or mutations.

class: a grouping of biological Orders with similar characteristics.

coniferous: cone-bearing, as with pine or cedar trees.

conservation: the protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

D

deciduous: trees that shed their leaves once a year.

decomposition: the breakdown of matter by bacteria and fungi.

degrading: progressive deterioration of physical characteristics.

detritus: partially decomposed organic matter.

dissolved oxygen (DO): a measure of the amount of oxygen available for bichemical activity in a given amount of water. Adequate levels of DO are needed to support aquatic life. Low DO concentrations can result from inadequate waste treatment.

dredging: to remove earth from the bottom of water bodies using a scooping machine.

E

ecology: the relationship of living things to one another and to their environments, or the study of such relationships.

ecosystem: the interacting system of a biological community and its nonliving surroundings.

effluent: waste material (i.e., liquid industrial refuse, sewage) discharged into the environment.

emergent plants: plants, rooted in the bottom of a lake or wetland, that rise above the water surface.

environment: the sum of all external conditions affecting the life, development and survival of an organism.

epilimnion: the upper, warm layer of a stratified lake.

erosion: the wearing away of land by wind or water.

eutrophic: a highly productive, nutrient-overloaded lake.

eutrophication: the process whereby a lake becomes highly productive. *Natural eutrophication* occurs when nutrients are circulated throughout a lake during turnover. *Cultural eutrophication* occurs when nutrients are added to a lake or wetland from agricultural runoff, sewage or other sources.

F

floodplain: low area of land, surrounding waterbodies, which holds the overflow of water during a flood.

food chain: the transfer of food energy from the primary source, plants, through a series of organisms repeatedly eating and being eaten. For example, algae to aquatic insects to small fish to larger fish to fish-eating birds to mammals.

forested wetland: a wetland dominated by trees over twenty feet in height.

G

groundwater: a supply of fresh water under the earth's surface which forms a natural reservoir.

groundwater recharge: the process whereby water seeps into the ground in certain areas to replenish the groundwater supply.

H

habitat: the sum of environmental conditions in a specific place that is occupied by an organism, population or community.

hardness of water: a physical-chemical characteristic that is commonly recognized by the increased quantity of soap required to produce lather. Mainly, it comes from the presence of calcium and magnesium.

heavy metals: metallic elements like mercury, chromium, cadmium, arsenic, and lead, with high molecular weights. They can damage living things at low concentrations and tend to accumulate in the food chain.

hydrophytes: plants adapted to living the low-oxygen conditions of water saturated soils.

hypolimnion: .the lower, cold layer of a stratified lake.

I

indicator: in biology, an organism, species, or community that shows the presence of certain environmental conditions.

inorganic: in chemistry, any compound not containing carbon.

L

larva: the early, free-living, immature form of an animal.

lead: a heavy metal that may be hazardous to health if breathed or swallowed

limnology: the science that deals with the physical, chemical, and biological properties and processes of fresh waters.

littoral zone: the shallow region of a body of water, from the highest seasonal water level to the depth where light cannot reach bottom.

M

macrobenthic organisms: animals living in or on the bottom of a body of water that are large enough to be seen with the naked eye.

macroinvertibrate: animals without a backbone that are large enough to be seen by the naked eye.

macrophytes: the large (macro) plants of a lake or wetland (compare with the phytoplankton).

marsh: a treeless wetland occupied by grasses, rushes, sedges and other aquatic plants.

mesotrophic: a moderately productive lake.

monitoring: to watch and care for a body of water on a regular basis.

mutation: a change in an inheritable characteristic of an individual.

N

nekton: the fish and other free-swimming animals in a body of water.

nocturnal: active at night.

non-point source pollution: a type of pollution whose source is not readily identifiable such as pollution caused by car exhaust, carried off city streets by rainwater (see point source pollution).

nutrient: substance which is necessary for the growth of all living things (i.e., oxygen, nitrogen and carbon).

nymph: the young stage of an insect which undergoes simple metamorphosis.

O

oligotrophic: an unproductive lake.

order: a grouping of biological Families of organisms with similar characteristics.

organic: referring to or derived from living organisms. In chemistry, any compound containing carbon.

P

parasitic: a mode of life whereby a plant or animal lives in or on another organism (the host) and derives its food from the host.

PCB: polychlorinated biphenyl; a toxic substance of the chlorinated hydrocarbon group capable of causing numerous reactions in humans, including death.

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pelagic zone: in a lake, the region of free, open water.

pesticide: a chemical that kills animal or plant pests.

pH: a measure of the acidity or alkalinity of a material, liquid or solid. pH is represented on a scale of 0 (most acid), to 14 (most alkaline) with a reading of 7 being neutral.

phosphorus: an essential food element that can contribute to the eutrophication of water bodies.

phytoplankton: tiny aquatic plants that aquatic invertebrates and fish feed upon.

plankton: tiny plants and animals that live in water.

point source pollution: a type of pollution that can be tracked down to an easily noticeable cause such as discharging pipes, and people putting chemicals and trash into the water (see non-point source pollution).

pollutant: something that makes land, water and air dirty and unhealthy.

pollution: the presence of waste that makes the world around us dirty and contaminated.

pond: a small lake, usually shallow enough to allow growth of rooted plants from one shore to the other.

predatory: living by capturing and feeding upon other animals (the prey).

prey: an animal hunted or killed by another animal (the predator).

R

reservoir: any holding area, natural or artificial, used to store, regulate or control water.

riparian: the area adjacent to streams, lakes, wetlands, etc.

runoff: water from rain, snow melt, or irrigation that flows over the ground surface and returns to streams, lakes or wetlands. It can collect pollutants from air or land and carry them to the receiving waters.

S

scavenger: an animal that eats refuse and decaying organic matter.

scrub/shrub wetland: a wetland dominated by small trees and shrubs less than twenty feet in height.

sediment: soil, sand, and minerals washed from land into waterways.

sedimentation: the process whereby soil particles (sediment) settle to the bottom of a waterway or water body.

sewage: the organic waste and wastewater produced by residental and commercial establishments.

sewer: a channel or pipe that carries wastewater and storm-water runoff from the source to a treatment plant or receiving stream.

silt: fine particles of soil or rock that can be picked up by air or water and deposited as sediment.

siltation: the process of silt settling out of the water to the bottom of a lake or wetland.

sludge beds: any heavy, slimy deposit.

storm sewer: a system that collects and carries rain and snow runoff to a point where it can seep into the groundwater or flow into surface waters.

stratification: the layering of a lake caused by temperature differences between surface and deep water (also called thermal stratification).

substrate: solid material upon which an organism lives or to which it is attached.

swamp: common name for a scrub/shrub or forested wetland.

T

terrestrial: living on land rather than in water.

thermocline: the region of rapid temperature change between upper (warmer) water and lower (colder) water in a stratified lake.

toxic substances: poisonous matter (either human-made or natural) which causes sickness, disease and/or death to plants or animals.

toxicity: the degree of danger posed by a substance to animal or plant life.

turbidity: a cloudy condition in water due to suspended silt or organic material.

turnover: mixing of a lake from top to bottom. Usually occurs in Spring and Autumn when the lake is not stratified.

U

urban runoff: storm water from city streets, usually carrying litter and organic wastes.

W

waste: unwanted materials left over from manufacturing processes; refuse from places of human or animal habitation.

wastewater: water carrying dissolved or suspended solids from homes, farms, businesses and industries.

water pollution: the addition of enough objectionable material to damage water quality.

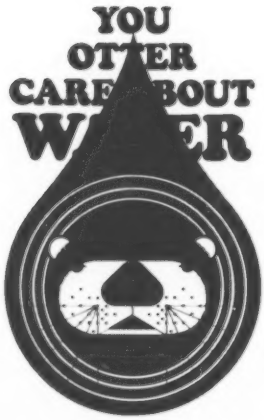
water quality standard: a management tool that 1) considers what water will be used for, 2) sets levels to protect those uses, 3) implements and enforces water treatment plants and 4) protects existing high quality waters.

watershed: all the land that serves as a drainage area for a specific stream, river, lake or wetland.

wetland: an area covered with shallow water or with saturated soil at least part of the year.

Z

zooplankton: tiny aquatic animals that fish feed on.



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